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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

INTERNATIONAL AVIATION

(Selected Articles)

FOREIGN TECHNOLOGY DIVISION

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(Selected Articles)

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TITLE: WING FINS "DEVELOPING TOWARD SHARP POINTS"

The triangular aircraft wing arrangement with no tail is one of the set ups with the best outlook for development in supersonic tactical fighter aircraft. It has low wave resistance, high structural efficiency, large interior volume, strong capabilities for hanging external loads, and other similar advantages. It is only relatively deficient in the ability to control vertical aerodynamic forces and trim characteristics. The result of this is that there is nothing else to do but to position systems or apparatuses with strong, high rear edge lift in order to obtain relatively small field approach speeds. When at large angles of attack, one also sees, due to a deficiency in adequate power limits on moments of aerodynamic forces on the low nose--particularly in relaxed, stable conditions--very severely limited maneuver capabilities in the aircraft.

Such people as Huo Fu from the U.S. Hanpudun (phonetic approximation) Weigan (phonetic approximation) Combined Research Company and the Air Force Laite (phonetic approximation) (illegible) Aviation Laboratory and others brought up a type of concept called "wing fins developing or deploying toward sharp points" (Fig.1). This type of wing fin is hinged on the inside of the forward edge of the aircraft wings. When they are opened, they are perpendicular to the surface of the wings (generally, the forward edge vortical flaps open downward). Because of this, even if one has a small angle of attack, and, when the forward edge vortices of the wings are correspondingly relatively weak, the left (unclear) and right wing fins are also capable of producing a pair of violently strong rotating vortical flows moving in opposite directions. They develop along the direction of the forward edge and produce clearly evident vortical lift. As a result, they provide a moment of force lifting the nose, which is very advantageous to trim. In addition, when used in conjunction with the rear edge flaps, it is possible to effectively reduce the landing speed of approach to the field. Moreover, when the vortical flows on the front edge of wings are relatively strong, in conditions where the angle of attack is large, these wing fin vortical flows not only change and become relatively weak, they also drift very, very high on the wings. The result causes the lift forces of the forward edge development area to be reduced. This will also produce a desirable moment of force on the low nose and be advantageous for the aircraft's returning even more quickly to a normal flight attitude. In other flight attitudes, they can stick close to aircraft wing surfaces and will not influence the unique capabilities and advantages of the tailless triangular wing.

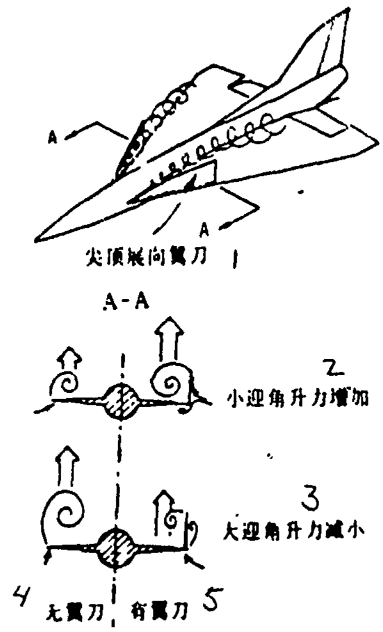

Fig.1 Diagram of Wing Fin Structure Deploying Pointed Tops Upward
(1) Wing Fin Pointed Tops Deploying Upward (2) Added Lift Forces With Small Angles of Attack (3) Reduced Lift Forces With Large Angles of Attack (4) No Wing Fins (5) With Wing Fins

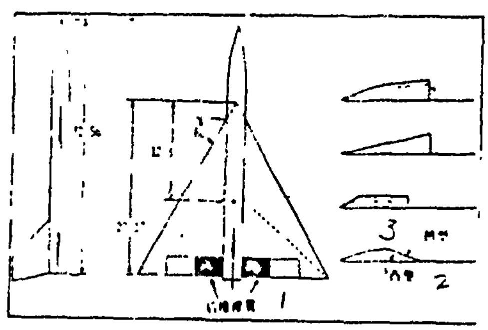

Fig.2 Model Used for Tests Measuring Forces and Form of Wing Fins
(1) Rear Edge Flaps (2) Convex Form (3) Concave Form

In order to empirically verify the effectiveness of this concept, Huo Fu and other similar people used a triangular wing to carry out measurements of forces, measurements of pressures, and test observations of hydraulic flow. All the results obtained uniformly demonstrated the predicted results. This article only introduces the principal results of the measurements of forces.

Fig.2 is the form of the model and wing fins used. Fig.3 - Fig.6 are several sets of typical force measurement results.

From Fig.3, it can be seen that the amount of the increase in the positive direction (moment of force lifting the nose) produced by the wing fins, right through to before the angle of attack is 20°, is basically maintained as a constant. Moreover, the size of its order of magnitude is not only related to the size of the wing fins, but to their form as well.

Fig.4 (above) also, in particular, induces, when the angle of attack is 12°, a comparison of the trim lift coefficients for different wing fins. The lift forces here are principally supplied from the rear edge flaps. Different wing fin lift forces require different rear edge flap lift forces in order to acheive the moments of force for trim. From the Fig. in question it is possible to see that the supplying of trim lift forces, basically, forms a positive proportion or ratio with the surface area of the wing fins. From an analysis of the effects of their forms, one can come to the preliminary recognition that the effects of a double arch shape seem even better (that is, a relatively small surface area is capable of obtaining relatively large trim lift forces). However, a more thorough study of even better exterior forms is still significant. From Fig.4 (lower) it is also possible to see that the amount of increase in trim lift forces, relative to all wing fins, are capable, in all cases, of maintaining a constant numerical value before angles of attack are at 20°.

Due to the fact that the triangular wing set up with no tail is inherently statically unstable, in general situations, it is necessary to take the rear edge flaps and put them off center. Only then is it possible to maintain aircraft trim. This, necessarily, will carry with it an increase in angle of attack in order to compensate for the lack of lift forces which comes with the offset on the flaps. However, after the addition of wing fins developing or deploying to a sharp top, it is not only possible to adjust the lift forces, but it is also possible to supply the moments of force which are desired. For example, during situations in which one is in configurations with large angles of attack approaching a field, it will produce a desired downward moment of offseting force. Because of this, the trim deviation angle of rotation of the rear edge flaps can be reduced. The aircraft angle of attack can also be reduced. As far as estimates for whole aircraft on which have been installed arch shaped wing fins are concerned, they clearly show that, in situations in which trim lift force coefficients are all 0.5, wing fins can cause angles of attack to be reduced to 6°.

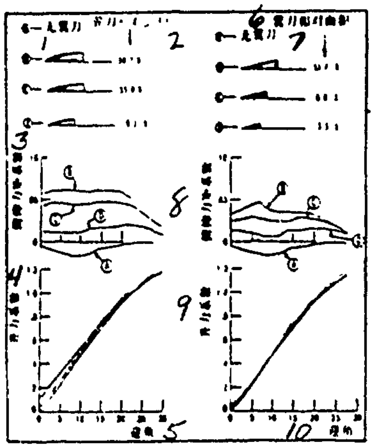

Fig 3. Lift Forces and Moment of Forces Characteristics for Two Types of Wing Fins (1) No Wing Fins (2) Surface Area Corresponding to Wing Fins (3) Moment of Pitch Force Coefficients (4) Moments of Lift Force (5) Angle of Attack (6) Surface Area Corresponding to Wing Fins (7) No Wing Fins (8) Coefficients of Pitch Force Moments (9) Coefficients of Lift Forces (10) Angle of Attack

Vortical flows produced by wing fins will also bring with them certain resistance forces or drag. From Fig.4 (lower) it is possible to see that, when lift coefficients are high, the ratios of lift to drag with wing fins and without tend to be in line with each other. This is reflected in the same way for the same coefficients of lift. Because of the fact that, when there are wing fins, the angles of attack which are required on the aircraft are relatively small, the drag forces are also relatively small, compensating for the increase in resistance forces which comes with wing fins.

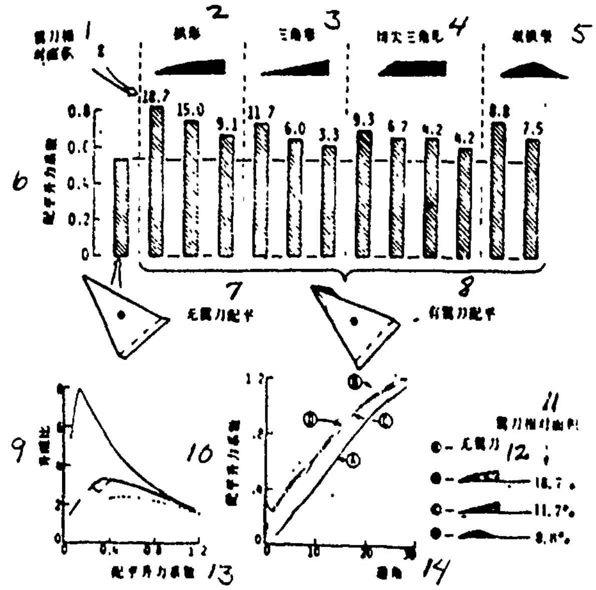

Fig.4 Comparison of Effects (Top) and Lift-Drag Characteristics (Bottom) for Different States of Wing Fin Trim Lift Forces (1) Surface Area Corresponding to Wing Fins (2) Arch Shape (3) Triangualar Shape (4) Sharp Cut Triangular Shape (5) Double Arch Shape (6) Trim Lift Force Coefficients (7) Trim Withou Wing Fins (8) Trim With Wing Fins (9) Lift-Drag Ratio (10) Trim Lift Force Coefficients (11) Surface Area Corresponding to Wing Fins (12) No Wing Fins (13) Trim Lift Force Coefficients (14) Angle of Attack

Fig.5 is typical force moment characteristics for large angles of attack. It is possible to see that, for the interval between angles of attack of 28°-40°, the increase in the amounts of moments of pitch force turn from positive to negative. The orders of magnitude and changes in sign of angles of attack can be seen as determined by the dimensions and form of the wing fins. Because of this, it is possible to take the deployment of the wing fins to act as a natural design for limiting the angle of attack.

During side slip in flight, because the surface of the wing fins meeting the wind has vortical flow lateral forces of divergence which are reduced, the effects on the leeward surface of the wing fins is just the opposite. The lateral forces increase. Finally, a stable moment of flight deviation forces is produced. At the same time, due to the fact that the forward edge vortical flows on the main wing surfaces meeting the wind increase in strength, the rolling and turning moments of force which are produced increase in amount and are also stable (Fig.5 Right).

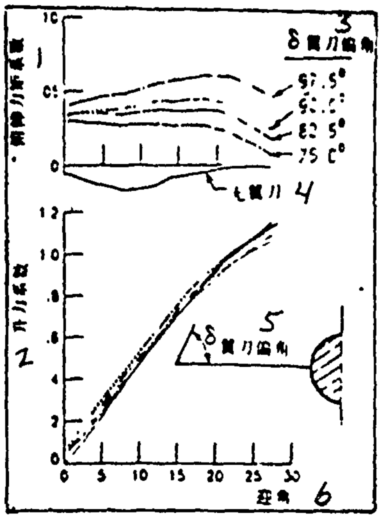

Fig.6 Effects of Wing Fin Deviation Angle on Moment of Forces Characteristics (1) Moment of Pitch Forces Coefficient (2) Lift Force Coefficients (3) Wing Fin Deviation or Offset Angles (4) No Wing Fins (5) Wing Fin Deviation or Offset Angle (6) Angle of Attack

Huo Fu also carried out wing fin deviation or offset angle effect tests. The results clearly show that deviation angle control over moments of pitch force is almost linear (Fig.6).

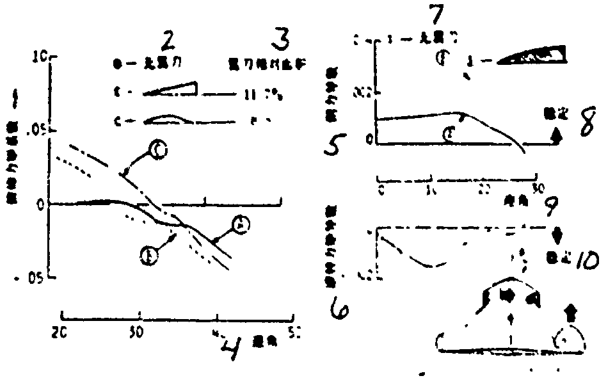

Fig.5 Typical Moment of Pitch Force Characteristics for Large Angles of Attack (Left) and Moment of Lateral Force Characteristics (Right) (1) Moment of Pitch Force Coefficients (2) No Wing Fins (3) Surface Area Corresponding to Wing Fins (4) Angle of Attack (5) Lateral Force Derivatives (6) Moment of Rolling and Turning Forces Derivatives (7) No Wing Fins (8) Stability (9) Angle of Attack (10) Stability

COOPERATION, REORGANIZATION, AND TECHNOLOGICAL TRANSFORMATION THE PATH THE AIRCRAFT ENGINE INDUSTRY MUST TAKE TOWARD MODERNIZATION

(PART II)

UNCEASINGLY CARRY OUT TECHNOLOGICAL TRANSFORMATION

On the foundation of the rationalization of the structure of production, the ceaseless renewing of industrial techniques and the renovation of equipment are key measures to lower production costs. The engine plants and companies of various nations have all spent heavily to carry out technological transformation.

Beginning in 1981, the Pu-Hui (phonetic) Company (possibly General Dynamics) developed an ambitious and vigorous modernization plan, investing a billion U.S. dollars to be used in the transformation of plants and equipment. By 1987, the investment of 500 million U.S. dollars had already been completed, and the remainder will be completed before 1991.

From 1981-1984, in Columbus, Georgia, they constructed a highly automated, large scale foundry facility with an area of approximately 70 thousand square meters. Production is controled by 100 computers and 50 robots. In total, there are only 750 operating personnel. In 1988, the amount of production reached 650 thousand compressor blades and 9000 discs. The facility or base in question is now in the process of striving to reach a design production target of 1 million 300 thousand blades and 12 thousand discs. New measures in the arenas of raising the quality of products and shortening the period of production have shown clear results. The luminosity or smoothness of surface areas on titanium alloy compressor blades and the precision of their dimensions have gone very high. The processing or working tolerances on castings of high strength, high heat alloy powder metallurgy discs have been greatly reduced, and automation has been realized without testing damage. In the area of production period, compressor blades have been reduced 50%, and discs have been reduced 33%.

At the Shaoxindun (phonetic) plant, they set up 4 disc axis processing lines, and, in total, installed 80 pieces of new equipment. In the newly constructed drum processing area, they installed 3 large model inert gas safety welding devices, 3 electron beam welding devices, 2 processing or working centers, and 12 special types of heat processing ovens. According to the plan, it will reach a final capability for a yearly production of 3000 compressor rotor drums.

At the Mideerdun (phonetic, possibly Middleton) plant the transformation plan for the shop that does precision forging of blades, which was begun in 1985, will be completed within the year. At the present time, there are already 10 robots in operation. The transformation plan for the computer control of automated smelting furnaces is in the midst of being implemented. This plan will cause a great change in the production of precision cast blades. These facilities will, in engines for military and civilian use, provide directionally congealed, single crystal high pressure cast turbine blades. The civilian aircraft assembly shop at the Mideerdun (phonetic, possibly Middleton) plant has also carried out adjustments, expanded its area, transformed its lighting and surface as well its rotor balancing center, and installed rotor blade tip grinding equipment. As far as test bed data processing computer systems are conerned, based on their introduction, they will need to be renovated on the average of once every 4 years.

At the Nosiheiwen (phonetic, possibly Northhaven) plant, they constructed a factory for the automated processing of turbine blades at an investment of 70 million U.S. dollars, including 12 computer controlled automatic grinding machines and their auxilliary equipment. This equipment is ordered as required from the West German BLOHM Company which specializes in its design and manufacture. 8 sets have already been put into use. The projects in question were put into effect in 1984, and it can be expected that they will be completely finished in 1990. After transformation, the amount of blades produced increases, dimensions can be controlled even better, the rate of waste can be reduced to 0.1%, and machining time and production period can both be clearly reduced.

In handling specializations, the Pu-hui (phonetic, possibly General Dynamics) Canada Company, which produces small model engines, beginning in 1986, constructed, in Halifax, in Eastern Canada, a huge new automated factory--Branch Plant No.41. This plant is completely composed of processing centers and other similar types of numerically controlled machine tools. 4 computer controlled, automated transportation vehicles, according to program, take parts that have finished their processing from the machine tools, pick them up and send them to another machine tool. Going through test operation in 1988, the multitudinous difficulties and problems associated with such areas as software, hardware, and familiarization of personnel with operations were overcome. In 1989, they gradually moved toward normal operation.

It can be seen that the Pu-hui (phonetic, possibly General Dynamics) Company has expended huge effort in order to increase the competitive capabilities of its products and on the area of technological transformation.

The U.S General Electric Company has always attached great importance to measures to improve production. It has gone through the drafting of a project for what it calls the "factory of the future", that is, a fully automated factory. In various individual satellite plants, they also set up high efficiency specialized production lines. For example, in their factory in Wilmington, North Carolina, they are just in the midst of constructing transmission part assembly lines composed of 16 numerically controlled vertical machine tools, a housing production line composed of 12 numerically controlled vertical machine tools, 16 numerically controlled processing centers, and instruments, as well as a relatively small scale automatic production line for burring. All the various production lines are equipped with automatic vehicles for moving parts and computer controlled storage systems. Within the factory, the various types of processing and fault detection equipment are also all computer controlled. Operating efficiency is relatively high.

The Luo-luo (phonetic, possibly Rolls Royce) Company, in the last ten years, also carried out considerable technological transformation, going through, in succession, the construction, in Dhabi (phonetic), of an advanced integrated manufacturing system (AIMS)--that is, a computer managed machine shop for the automated processing of disc type parts, an automatic line for the grinding of turbine blades, the construction, in Bulisituoer (phonetic), of a compressor blade 360° electrolytic processing or machining production line, the construction, in Hailingtun (phonetic, possibly Highlington), of a rectified blade axis neck processing or machining production line composed of a low melting point alloy casting machine and 3 West German TRAUB Company turning centers. Besides this, the Luo-Luo (phonetic, possibly Rolls Royce) Company also constructed a fan disc circular arc tenon and trough milling and grinding machining line composed of 2 numerically controlled vertical machine tools, 5 sets of 5 coordinate machining centers, and 1 projection instrument, a small blade aperture machining production line composed of 4 sets of 5 coordinate numerically controlled electric spark machine tools, and other similar facilities. These advanced measures, for guaranteeing the manufacturing quality of extremely complicated parts, shortening the period of manufacture and work time, acheived clear results. The company in question has shown, in order to maintain the competitive power of the products, that this type of technological transformation will continue to be carried out.

The French SNECMA Company, in the 1970s and early 1980s, in order to appropriately respond to the requirements of the cooperative production of the CFM56 engine, carried out large scale transformations. The company in question reformed, and, in conjunction with that, expanded by the construction of a precision blade casting and forging machine shop, the new construction of a blade processing machine shop, the installation of large lot numerically controlled milling machine tools, the formation of grinding machines, electric spark processing or machining tools, and other similar advanced equipment. It expanded with the construction of assembly machine shops and newly constructed advanced test beds. In the parts manufacturing plant at Kebeier (phonetic), they installed over 300 numerically controlled machine tools and various types of special industrial technology measures or facilities. A good deal of equipment brought manipulators in with it. For example, there was one 11 coordinate de-burring manipulator. It was capable of completing extremely complicated de-burring programs and calling people to observe and stop it.

West Germany's MTU is quite a late but rapidly rising engine company. In the arena of technological transformation, it has invested very great energy. Its new industrial technology plant was

just completed not long ago. On the plant's first floor, is arranged the disc type part processing or machining. On the second floor, the blade production is set out. It also plans to install complete sets of numerically controlled automated equipment connected to manipulators. A turbine disc testing automated line composed of 4 numerically controlled coordinate measuring instruments as well as
automatic transportation and storage systems has already been 51
in use for many years. These production lines operate 7 days a week, 24 hours a day, continuously, and leave an observer with a deep impression.

At the same time that various plants and companies were investing to construct advanced facilities, they were still using mass production equipment which was already operating and was more than 20 or 30 years old. This old equipment, by going through good maintenance, is still in excellent condition. On this point, one need not have any misunderstanding at all.

HOW THE AVIATION ENGINE INDUSTRY OF CHINA MUST MOVE TOWARD MODERNIZATION

The cases intoduced above are, perhaps, nothing else than the paths that the key aviation engine plants and companies or firms have taken toward modernization, that is, seeking out cooperative and joint development of new products--reorganizing production structures making them rationalized--transforming production facilities, unceasingly opting for the use of new industrial techniques and new equipment. The objective of all these efforts is to strengthen competitive power. Looking at the modernization of the Chinese aviation industry, it is also necessary to follow this road. Of course, as a developing nation, due to international political relationships, the national economic foundation and technological foundation, as well as the scale of the market, our path also has a large number of special characteristics.

As far as international cooperation is concerned, at the present time, the key is the realm of engines for civilian aviation. This can include propulsion for aircraft on trunk lines, propulsion for aircraft on branch lines, and auxilliary propulsion equipment, industrial gas turbines and other similar areas. The main forms of cooperation are cooperative production and production of transfer packages. Under conditions where it is possible, one can have adoption competitions with a number of cooperative production and transformation projects participating, and other similar activities. When conditions permit, one should also have competitions for adoption with projects for cooperation in the area of military aviation engines participating. However, in this area, the standpoint should be placed on autonomous test production.

Reorganization should be the main point of the current revolution in enterprises. According to principles of specialization, the restructuring of production in enterprises is an extremely complicated process, involving many systemic problems and problems of benefit or profit. However, we are not able to sit down and get familiarized with conditions such as these. We must get up immediately and act. At the present time, we are forcing the working out of the necessary projects, aggressively creating conditions, taking practical steps one after the other, within the time limit stipulated, to complete the reorganization and the important task of these projects which will influence the future outlook, success, and failure of the Chinese aviation industry. We must, step by step, take the development of aviation products and non-aviation products and separate production, and, step by step, take the scientific research development and production power of the aviation engine industry in all of China and organize mutual coordination, and a mutually complementing organic whole. The success of this reorganization will form the foundation stone for the take off of the Chinese aviation industry.

Technology transformation is a continuously executed process. In the past, we have already carried out quite a bit of work and achieved a certain success. However, what needs to be pointed out is that, due to the fact that, in the areas of the overall product project plans and the rationalization of production layouts, we still find deficiencies. We have also had no small number of mistakes. Expensive imported equipment has sat idle for long periods, the construction of a number of facilities has been disjointed, and the cost effectiveness of construction investment has been very bad. These problems are worth our sincere consideration and solution.

On the road of the Chinese aviation industry toward modernization, there are many things to do. Among the myriad important questions that need to be resolved, the leading one, the one in first place, is market research and market development or promotion. Market conditions change from moment to moment, and competition is fierce. Doing market research and market promotion well is not an easy job. The various aviation product firms outside of China, without exception, spend a great deal of time doing this kind of work. We must select the most capable people and send them to study and make this a reality.

China is a developing country, and the funds that it is possible to use in the development of aviation enterprises are limited. However, China is also a large nation. If it is possible to take the funds which can be gotten and concentrate them for use, this will be conducive to getting a few things done in a solid and down-to-earth way. Our problem lies in not giving serious enough attention to market research. We have been unable to take the limited funds and concentrate them for use in projects which have a good market future. Our creation of product models has been disjointed. The construction of scientific research and production facilities has been uncoordinated. The results from manufacturing investment have been off the mark, and there has been a vicious cycle of shortage of funds. Because of this, now and in the future, the development of product models and basic construction of technological manufacturing projects need to immediately take market requirements as their key basis.

At the present time, the world civilian aircraft industry is just in the midst of a flourishing time. Military aviation and specialized aviation also have good prospects. For the overall shape of the reforms it is starting, there are objective requirements which exist related to the development of aviation industry. It is only necessary to be able to go along this path accurately, and China's aviation industry will then be capable of siezing the moment, greatly developing her own strength, and making her own contributions to the needs of the market outside of China.

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